# ELECTRONS CROSS TRANSFER IN MULTISLIT ELECTROMAGNETIC TRAP “JUPITER 2M”

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The researches of cross electrons transfer in the central and face parts of a trap are carried out. It is shown, that increased electrons transfer in a face part is connected to presence here toroidal area of the superseded magnetic field. The change of a magnetic configuration has resulted in reduction of a cross electrons transfer in a face part, increase of density and negative potential of plasma.

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Plasma in the electromagnetic trap “Jupiter 2M”[1] is created by neutral gas ionization with high-energy electrons injected through axial holes. Electrons are confined in a trap by an acute-angle magnetic field and system of locking electrodes in the magnetic slits, and ions – by negative volumetric charge of electrons. At high enough locking potential in magnetic slits electrons can leave a trap only as a result of diffusion through a magnetic field, and ions - through magnetic slits, where height of a potential barrier for them is less at the expense of potential depression of a volumetric electrons charge.

Electrons diffusion through a magnetic field is the basic process determining a plasma confinement in a trap, the losses of ions are arranged under electrons losses by self-coordinated change of potential barriers height in magnetic slits.

In the previous experiments it was noticed, that the electrons diffusion flow in a face part of a trap is much more, than in the central part. In figure 1 a current of electrons injection (1), the currents of electrons losses across a magnetic field in the central part (2) and face parts of a trap (3) are given.

*Fig. 1*

It is visible, that the electrons losses in a face part of a trap twice exceed losses in the central part of a trap, and the area of a magnetic surface limiting area of plasma accumulation in the central part is 8 times more, than in a face part (2,03 m$^2$ and 0,47 m$^2$ accordingly).

The results of numerical accounts of electrons losses and their dependences on size from magnetic field intensity and plasma density in the assumption of Coulomb collisions were compared to results of experimental researches for research of electrons losses character across a magnetic field.

The electrons flows across a magnetic field were registered on diaphragm, which limits area of plasma accumulation in a trap. The measurements of injection current, ions losses through magnetic slits, plasma density and potential were carried out simultaneously.

Plasma density was measured by a microwave interferometer, assembled in a Wharton circuit. Oscillogram of linear plasma density in radial section is submitted in fig. 2. The radial distribution of plasma density was measured by a single Langmuir probe in a mode of a ions current of saturation. Plasma potential was measured by a single Langmuir probe in a floating mode.

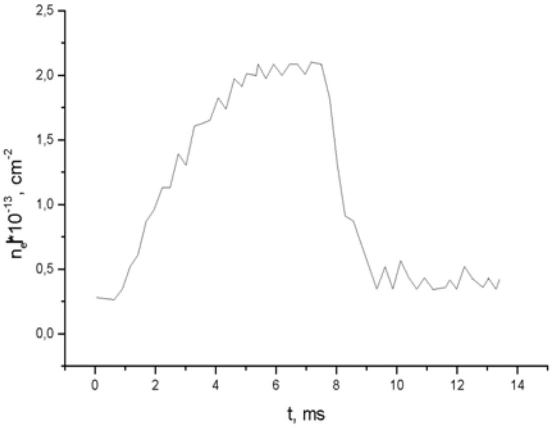

*Fig. 2*

The model of electrons transfer across a magnetic field for a multislit electromagnetic trap with axisymmetric magnetic field geometry in the assumption of Coulomb collisions was used for numerical accounts in view of electrons mobility in the electrical field. The flow of cross electrons transfer through a magnetic field in the central part of a trap is equal

$$I^{ц}_e = [D_{ea}(1+\Phi_p/2T_{e0})+D_{ei}]F_ц n_{e0}R^2 , \qquad (1)$$

and in a face part

$$I^{т}_e = [D_{ea}(1+\Phi_p/2T_{e0})+D_{ei}]F_к n_{e0}R^2 \qquad (2)$$

where: $D_{ea}$, $D_{ei}$ - factors of electrons diffusion on neutral gas and plasma flows, which are normalized to a magnetic field in a ring slit and plasma parameters in the central area; $\Phi_p$ - plasma potential (in power units); $F_ц$ and $F_k$ -

crest factors, taking into account real geometry of a magnetic field in a cylindrical central part and on the ends of a trap; R - ring magnetic slit radius. Factors of diffusion: $D_{ea}=9,1\cdot 10^{-7}n_aT_{e0}/B_A^2$, $D_{ei}=6,6\cdot 10^{-4}n_{e0}/T_{e0}^{1/2}B_A^2$, $n_{e0}$, $n_a$ - plasma density and neutral gas density, $cm^{-3}$; $T_e$ - electrons temperature, eV; $B_A$ - magnetic field in a ring magnetic slit, Gs. The accounts were carried out for a real magnetic configuration of a multislit electromagnetic trap "Jupiter 2M". For parameters "Jupiter 2M" $F_ц=92,7$; $F_k=171,6$ (at width of a ring magnetic slit $2a=0,4$ cm and radius of an axial aperture $r_0=1,3$ cm, $R=21,5$ cm). The experimental values of plasma density, neutral gas density, plasma potential and electrons temperature were used for accounts. As a result of accounts the flows of cross electrons losses from a trap in the central and face part and their dependence on plasma density and magnetic field intensity for real conditions of experiment of a multislit electromagnetic trap "Jupiter 2M" are received.

Theoretical and experimental dependence of an electrons flow across a magnetic field through a boundary surface in the central section of a trap from magnetic field intensity in a slit with plasma density in a trap $n_e = 4,5\times 10^{11}$ $cm^{-3}$ are given in fig. 3, theoretical and experimental dependence for a face part of a trap - in fig.4.

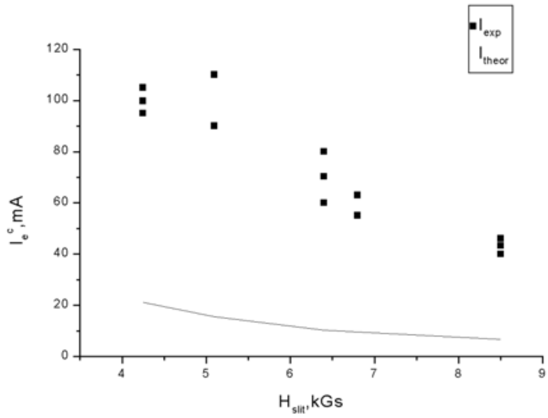

*Fig. 3*

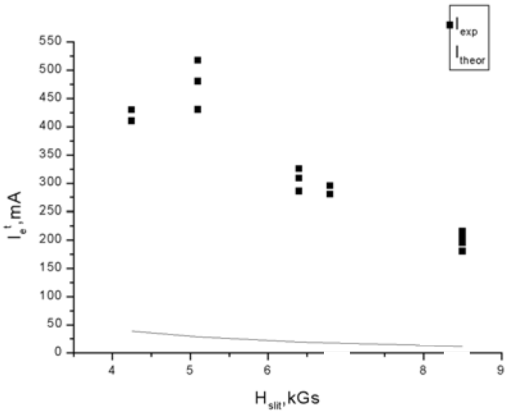

*Fig. 4*

The points on the diagrams represent experimental values of an electrons flow, and continuous line – theoretical ones.

The electrons flow across a magnetic field in the central section and face part of a trap grows with increase of plasma density, and decreases with growth of magnetic field intensity.

The experimental dependences of an electrons flow across a magnetic field in the central and face parts of a trap from plasma density are qualitatively similar, but they differ from theoretical dependences calculated in the assumption of Coulomb collisions. The relation of the measured cross electrons flow to calculated one is given in fig. 5. This relation decreases from value 10 - 15 to 2 - 2.5 with growth of plasma density from $10^{11}$ up to $10^{12}$ $cm^{-3}$.

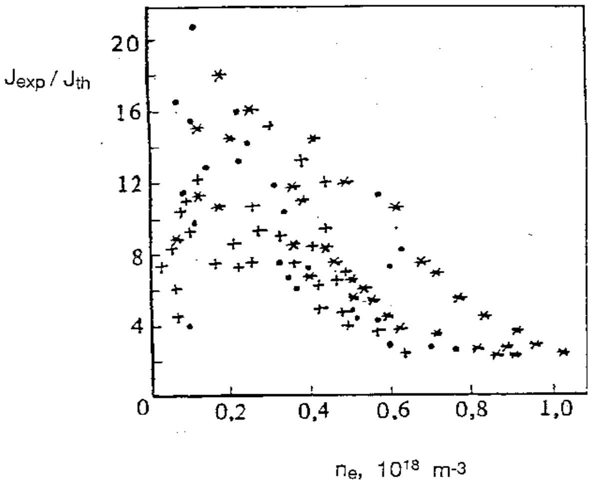

*Fig. 5*

Experimental dependences of an electrons flow across a magnetic field in the central and face parts of a trap from magnetic field intensity are qualitatively similar to theoretical dependences. But the experimental flows exceed theoretical. And in the central part of a trap at intensity of a magnetic field in a slit $H_{sl} = 8,5$ kGs and the plasma density $n_e = 1,2\times 10^{12}$ $cm^{-3}$ experimental flows exceed theoretical in 2,5 times, and in a face part - in 8 times. These results can be connected with a magnetic field configuration in the region where a face part interfaces with the central part of a trap.

In fig. 6 continuous lines show magnetic force lines of "Jupiter 2M" installation, and points - area of identical intensity of a magnetic field (20 Gs, 60 Gs, 120 Gs) for magnetic field intensity in a slit $H_{sl} = 8,5$ kGs. A-A - section of a microwave interferometer probing. It is visible from this figure, that the ring area of a zero magnetic field is formed in a face part of a trap. Large volume of non-magnetized plasma in face area can cause the large flow of particles through a face surface.

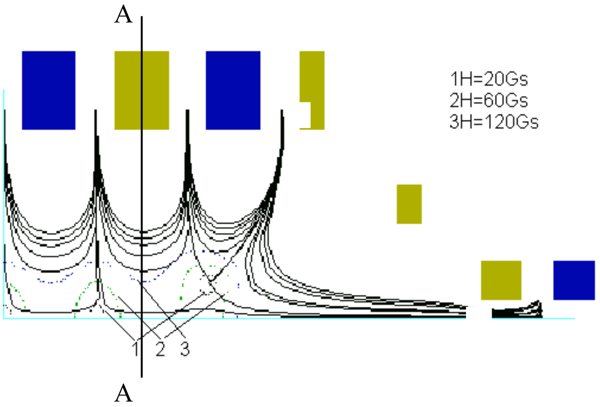

*Fig. 6*

Some variants of magnetic field configuration changes in a face part of a trap were counted. The variant with switching-off of interface coils (fig. 7) appeared to be most acceptable. In this case area of a zero magnetic field is displaced in the central paraxial area in section of a microwave interferometer probing A-A.

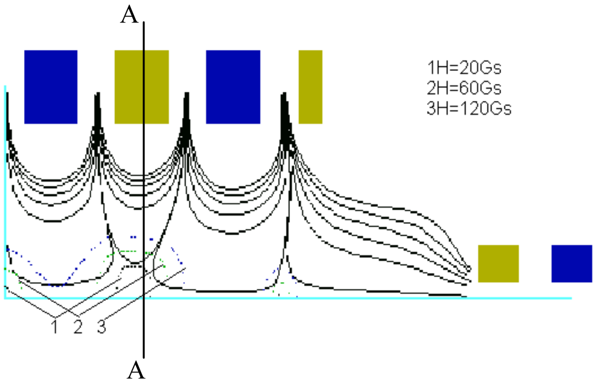

*Fig. 7*

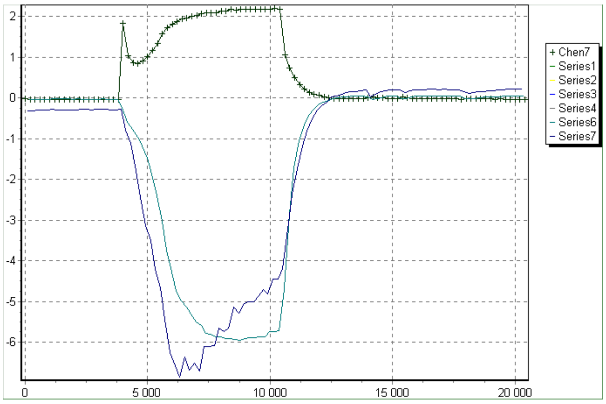

*Fig. 8*

The change of a magnetic field configuration resulted in change of a ratio of electrons flows losses in the central and face parts of a trap. The current of electrons injection (1), currents of electrons losses across a magnetic field in the central part (2) and face parts of a trap (3) for a new configuration of a magnetic field are given in fig. 8.

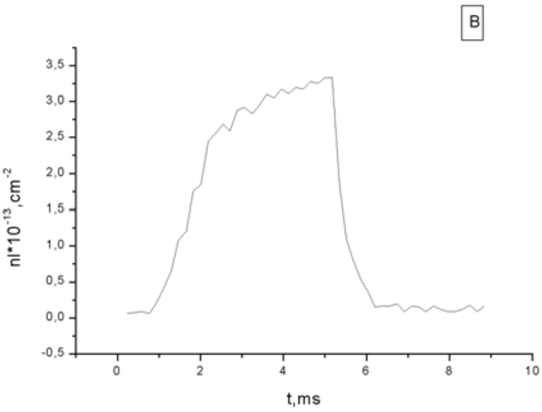

*Fig. 9*

At the same time linear density nl is increased in 1.5 times, fig. 9, and plasma potential is increased from $\Phi_p$ = 130 V up to $\Phi_p$ = 200 V.

## REFERENCES

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## ПОПЕРЕЧНЫЙ ПЕРЕНОС ЭЛЕКТРОНОВ В МНОГОЩЕЛЕВОЙ ЭЛЕКТРОМАГНИТНОЙ ЛОВУШКЕ "ЮПИТЕР 2М"

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Проведены исследования поперечного переноса электронов в центральной и торцевой частях ловушки. Показано, что повышенный перенос электронов в торцевой части связан с наличием здесь тороидальной области вытесненного магнитного поля. Изменение магнитной конфигурации привело к уменьшению поперечного потока электронов в торцевой части, увеличению плотности и отрицательного потенциала плазмы.

## ПОПЕРЕЧНИЙ ПЕРЕНОС ЕЛЕКТРОНІВ В БАГАТОЩІЛИННІЙ ЕЛЕКТРОМАГНІТНІЙ ПАСТЦІ "ЮПІТЕР 2М"

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Проведено дослідження поперечного переносу електронів у центральній і торцевій частинах пастки. Показано, що підвищений перенос електронів в торцевій частині пов'язаний з наявністю тут тороїдальної області витиснутого магнітного поля. Зміна магнітної конфігурації привела до зменшення поперечного потоку електронів у торцевій частині, збільшенню густини і негативного потенціалу плазми.